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PROPAGATION OF BAIT AND FORAGE FISH [1]

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INTRODUCTION

The propagation of bait in small artificially constructed ponds, or in natural ponds of limited area, is a simple task, and, with proper management, will provide a supply of bait that will justify the ex-

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pense of construction and maintenance. The facts and methods cited are intended as a guide to persons who wish to rear their own bait.

Bait dealers, as well as the general public, are becoming aware of the scarcity of forage fish in our inland waters. Old-time dealers, who in early days were kept supplied with minnows from our natural waters, are now complaining of the ever-dwindling supply of live bait. They are compelled to go long distances, seine for long and laborious hours and then often return with a small and inferior catch. It is also realized that the constant taking of minnows from our streams and lakes has not only reached the point where bait minnows are hard to get, but their scarcity is beginning to have an adverse effect upon game fish. Forage fish constitute the greater portion of the diet for our game fish and it is apparent that the depletion of game fish in our waters will discourage the angler so that the bait dealer is slowly losing his business.

Dealers who propagate their own bait, reserve the natural food supply in our waters for the game fish, and, in addition, they provide the angler with a better-conditioned bait. This better quality of bait is supplied by having the minnows at hand in their natural home, thus eliminating crowded conditions in the holding tank. Rearing ponds become holding tanks as well as a source of supply, and the transporting of minnows from distant streams, in crowded cans, is unnecessary.

DESCRIPTION OF MINNOWS

Minnows are a group that belong to a definite family of fish known as Cyprindae. There are other species of small fish, such as the mud minnow and brook silverside, belonging to other families, that are used as bait. However, the Cyprindae family contains the greatest number of bait species. A minnow is not just any small fish, as many people believe, nor is it the immature stage of some game fish. With the exception of a few species they seldom exceed a length of 10 inches. The best field character, to determine a minnow from a game fish, is the fin on the back. This fin on the true native minnow is soft, short, and has no spine. There are, however, other fish that have soft fins on their backs such as the suckers, whitefish, and trout. The fin on the back of the minnow is shorter than that on the sucker. The back fin is composed of rays, or supports, that hold it up. Our native species of the minnow family do not have more than 10 divided rays in their back fin.

Trout, whitefish, and other members of the Salmonidae family have a second fin on the back, which is absent in the minnow family. This is a small, soft, fatty fin known as the adipose, and is situated between the tail fin and the larger back fin.

THE IDEAL MINNOW

A good bait minnow must be active and hardy on the hook, and be able to withstand adverse conditions in the bait pail and holding tank. The brighter the coloration, the more attractive fishermen believe it to be to game fish, because the highly colored minnows may be seen for greater distances. This color may be a shade of yellow, red, green, or brown, or it may be of a silvery hue. The golden

shiner (*Notemigonus crysoleucas*), horned dace (*Semotilus atromaculatus*), common shiner (*Notropis cornutus*), and redfin (*Notropis lutrensis*) have become famous for bait because they possess the above qualities. In addition to the above-named species, there are other minnows that possess these qualities, such as the round shiner (*Hybognathus nuchalis*), red-bellied dace (*Chrosomus erythrogaster*), blunt-nosed minnow (*Hyborhynchus notatus*), black-head minnow (*Pimephales promelas*), and stoneroller (*Campostoma anomalum*). The carp, which is not indigenous in our waters, should not be used for bait, due to the danger of further distribution of this fish.

BEST SPECIES TO PROPAGATE

To select a species of minnow for propagation it is first necessary to determine what desirable species are native to the locality. For example, the redfin is native to the Southwest. Native species will usually do better than imported species. There are a few species that are native to all sections of the United States except the West coast. The golden shiner, horned dace, and blunt-nosed minnow are examples. They are among the best bait minnows.

MINNOWS POPULAR AMONG BAIT ANGLERS

In the fall of 1934 the Bureau of Fisheries sent a questionnaire to all chapters of the Izaak Walton League asking the anglers in the league to name the bait minnow each like best. The following is the order of preference: Golden shiner, horned dace, common shiner, mud minnow, and the blunt-nosed minnow. Detailed instructions for the propagation of these fish are being presented, with the exception of the mud minnow. The author has had no experience in the propagation of this species and was curious as to why so many anglers chose the mud minnow. It has never been recorded that they were taken in sufficient numbers in any body of water to give them prominence among bait fish. Specimens of mud minnows were requested from some of the anglers who chose this species. Upon receiving the specimens it was found that they were not mud minnows, but young *Amia calva*, commonly called bowfin, dogfish, or grindle. The use of the young of this predacious species for bait is absolutely unwise, since they are extremely voracious and take a heavy toll on the more desirable species of game and food fish.

COMMERCIAL PROPAGATION OF MINNOWS

WATER SUPPLY

Springs are the most desirable water source since they provide a constant supply. If the springs supply more water than is necessary to keep up the level in the ponds, part of the water should be bypassed. Only enough water should be used to keep a constant level. A large flow of spring water going into a pond will keep the water in the pond cool and wash the fertilizer and natural fish food from the pond through the overflow. If three or four ponds are built in series, enough water may flow through the first ponds to

keep up the level in the last pond, and this will tend to raise the temperature of the water. Many species of minnows increase their growth rate with a rise in water temperature from 70° to 90° F.

The tapping of creeks and rivers provides another excellent water supply. Whatever the source, all that is necessary is to have a supply large enough to keep up the water level in the pond.

POND CONSTRUCTION [2]

The construction of ponds must be planned in the light of available water supply and the contour of the land. They may be built by excavation or by throwing up dykes, or both. These methods require a great amount of labor and are often expensive. The damming up of a small creek valley into a series of ponds often makes an ideal set-up. The watershed, however, should not be too large, or flood waters may wash away the ponds and the fish will be lost. If there is a large watershed the ponds may be built by the side of the stream, and just enough water to keep up the level in the ponds may be piped by gravity from upstream. The pond farthest upstream may serve as a natural spawning ground for minnows like the common shiner. If the ponds are built in a small creek valley, the watershed should not be cultivated. Rain will wash the bare soil down into the ponds and roil the water. Roily water is detrimental both to fish life and to the natural growth of fish food. The watershed should be covered with a heavy grass or close-growing hay, or be forested. The fallen leaves of plants and trees decay, and the organic matter is dissolved and carried to the ponds by rainwater. This organic matter serves as food for the aquatic plant and animal life upon which the minnows feed. In fact, organic matter acts as a fertilizer, and it is just as necessary to fertilize water to get a good growth of fish as it is to fertilize soil to increase land crops. A forested or otherwise covered watershed will prevent rapid run-off during rainstorms and protect the ponds and fish from flood damage.

SIZE OF PONDS

Ponds may be of any size or shape. A pond 25 feet wide by 75 feet long will yield a good production of minnows. However, the ideal pond is from ¼ to 1 acre in area. If they are much larger they become unwieldy. Several small ponds are more satisfactory than one large one. They should be 1 foot deep at the shallow end and slope to a depth of 4 or 5 feet at the deep end. All ponds must be constructed so that they may be drained, since this is a primary requirement for good pond management.

The type of outlet depends upon the amount of water coming into the pond. If the water supply is limited an upright pipe outlet is best, for it is more conservative of the water. This type is shown in figure 1. Dam boards are not entirely satisfactory, for it is difficult to keep them from leaking. If there is floodwater to contend with, the catch-basin type of outlet is most satisfactory. Outlets must be screened and the screen of this type of outlet does not clog easily.

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[2] Detailed information on the construction of ponds is contained in Document No. 1056, "The Propagation of Pondfishes," by M. C. James, which may be secured from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 5 cents per copy.

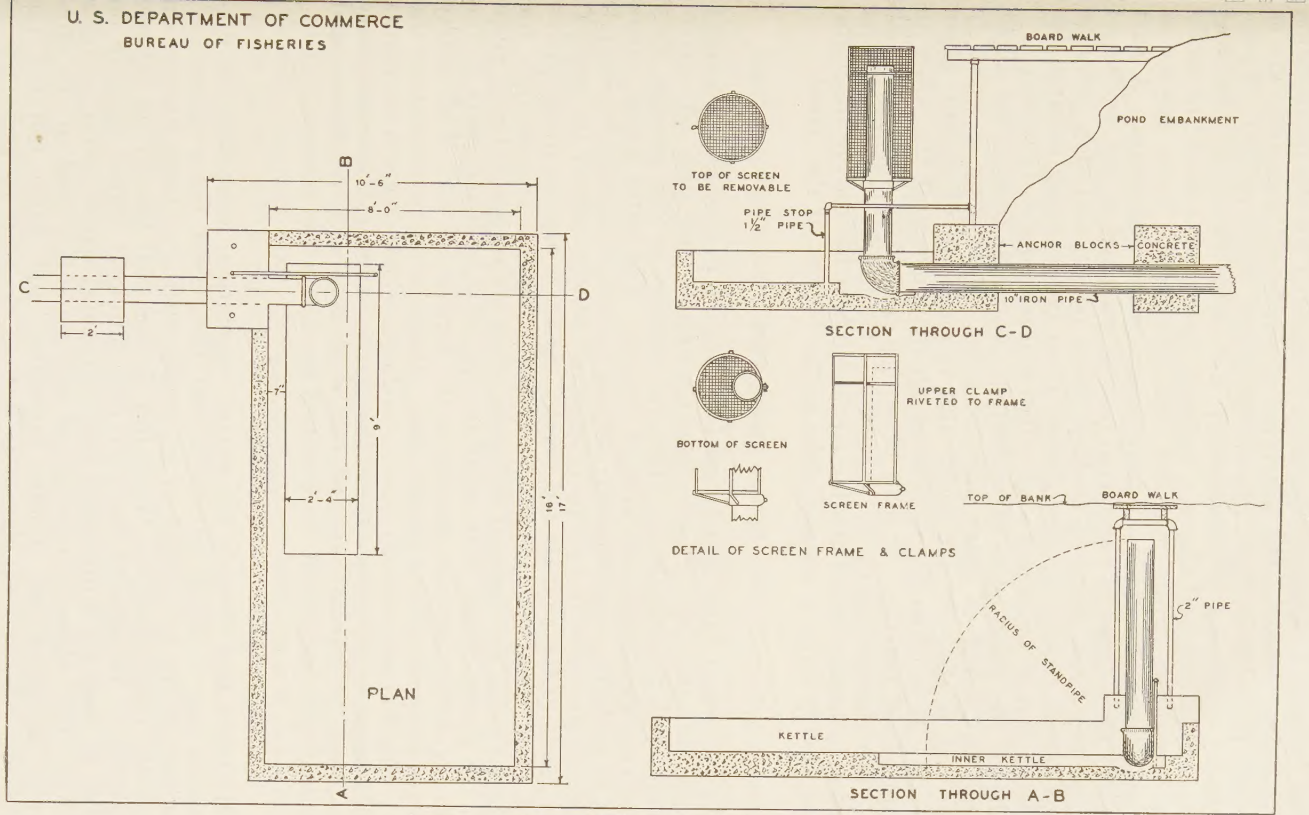

FIGURE 1.—Plan of Canfield "L" outlet and kettle.

SUITABLE TYPES OF AQUATIC VEGETATION

The presence of aquatic vegetation is essential for the propagation of minnows. Some of the best types of pondweed vegetation are as follows: Unicellular algae, filamentous algae, water milfoil (*Myriophyllum*), pondweed (*Potamogeton*), waterweed (*Elodea*), hornwort (*Ceratophyllum*), and Chara. Some of these plants should be established in ponds before minnows are introduced. Such species as golden shiners and redfins deposit their eggs on vegetation. A part or all of these types of vegetation may be collected in any section of the country from marshes, shallow lakes, ponds, and slow streams. These plants should not be collected from fast-running streams, for varieties that occur in fast water often will not do well in ponds.

One of the above types of vegetation, known as filamentous algae, should be present in every minnow pond. This plant is green in color. It is slimy to the touch and is made up of minute green threads. It is often found floating on the surface of the water in various-sized patches. It may be on the bottom of the pond with long strands reaching up to the surface. On bright days the greater portion is usually found floating on the surface, but during the night, or on cloudy days, it usually sinks to the bottom of the pond.

EXCESS VEGETATION

An important function of aquatic vegetation in a pond is to supply oxygen for the fish. Plants take up oxygen and give off carbon dioxide just as animals do. But, in addition to this process, they absorb carbon dioxide and give off oxygen. The latter action occurs only in sunlight. Consequently, during the hours of sunlight, enough oxygen is produced in a properly balanced pond to supply the respiratory needs of the animals and plants. If there are too many plants in a pond they will compete successfully against the animals for oxygen during the hours of darkness, when no oxygen is being given off. In ponds choked with algae the fish will be found early in the morning, before sunrise, gasping at the surface for air. This nearly always happens after a cloudy day. Under such circumstances the surviving fish act normally as soon as the sun comes out and the plants again begin to photo-synthesize the pond's oxygen. Therefore, only one-fourth of a pond's area should be planted with vegetation, and plant growth should not be permitted to exceed this amount.

FOOD SUPPLY

Minnows feed directly on aquatic vegetation, especially the filamentous type of algae, and the horned dace, which has a varied diet, has been grown to a length of 2½ inches during a single summer on a purely vegetable diet. Game fish do not feed heavily on aquatic vegetation. Because of the fact that minnows subsist largely on algae, its presence is important both in natural waters and in minnow ponds. This algae is transformed into game fish food by the minnows. Minnows eat aquatic vegetation and game fish eat the minnows. Aquatic vegetation is just as essential to game fish as green pastures are to man.

The presence of filamentous algae usually indicates that unicelluar algae also is present although it cannot be seen without the aid of a

microscope except where it is very abundant, in which case it imparts a greenish tinge to the water. Unicellular algae, and other coarser vegetation, are direct sources of food for small aquatic animals known as plankton. This plant and animal plankton is the most important food supply of both large and small minnows.

BREEDING STOCK

The securing of adult minnows for breeding stock is frequently the first obstacle encountered. Very few of the State hatcheries are able to furnish them, but occasionally private commercial pondfish hatcheries maintain a stock of the more common species, such as the golden shiner. Main reliance must be placed upon seining or trapping the adult stock from natural waters. State laws usually govern such an enterprise and inquiry should be made of the State conservation authorities to ascertain what regulations, if any, apply. Since the private propagation of bait is a desirable conservation measure, State officials will undoubtedly be as liberal as possible in authorizing the seining of breeding stock from public waters.

SPAWNING SITES

Aquatic vegetation serves as spawning sites for many species of minnows that spawn naturally in quiet water. Such minnows as the golden shiner and the redfin and red-bellied dace scatter their eggs over this vegetation. No production can be expected from these minnows without vegetation unless artificial-spawning mats are used. These mats may be sod, bundles of straw, or bundles of fine roots, but they do not give as good results as are obtained from natural vegetation.

Adult minnows often feed upon their young, and vegetation also provides hiding places where the young are given a chance to escape their cannibalistic parents and other enemies, such as kingfishers, wading birds and water snakes.

POND-SPAWNING MINNOWS

In nature, this group, consisting of the golden shiner, red-bellied dace, redfin, blunt-nosed, and black-head, spawn in the quiet water of lakes, ponds, streams, creeks, or rivers. When they are present in flowing streams, such as creeks or rivers, they spawn only in the quiet pools. These are excellent species for pond production.

VEGETATION-SPAWNING MINNOWS

The golden shiner and the redfin are examples of minnows that deposit their spawn on submerged plants. These species do not guard or otherwise take care of their eggs, but leave them as soon as they have been laid and fertilized, whereupon their parental duties are completed. This type of minnow is ideally adapted for pond culture. It is only necessary to place the breeders in a pond having vegetation, and natural propagation will take place. The minnows of this group are described as follows:

Golden shiner (*Notemigonus crysoleucas*).—This minnow is very popular among anglers in all sections of the country. Its golden-

colored sides and greenish back make it a very attractive fish. However, it does not attain this golden color until its second summer. The water in which it lives must be fairly clear to make the colors prominent. The larger individuals of golden shiners are excellent bait for pike and bass, and the small specimens are equally good for perch, crappie, and sunfish.

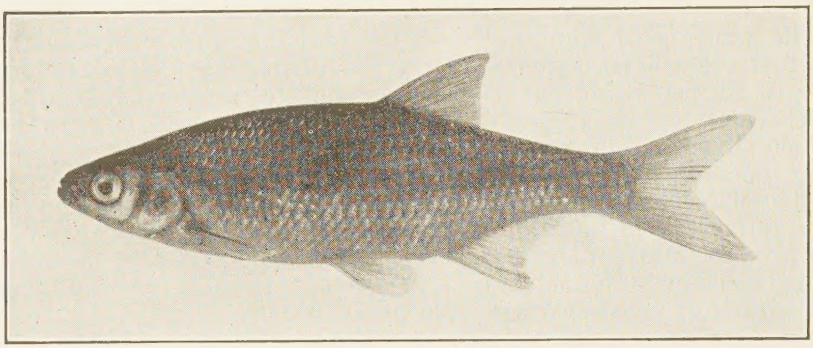

FIGURE 2.—Golden shiner (*Notemigonus crysoleucas*).

The golden shiner deposits its eggs on vegetation and usually begins spawning the first week in May in Ohio, Indiana, Illinois, and Iowa. The spawning season continues into August, although the heaviest spawning is in the month of May.

The golden shiner is a prolific spawner in ponds. At the Bureau of Fisheries hatchery at Fairport, Iowa, this species has been grown

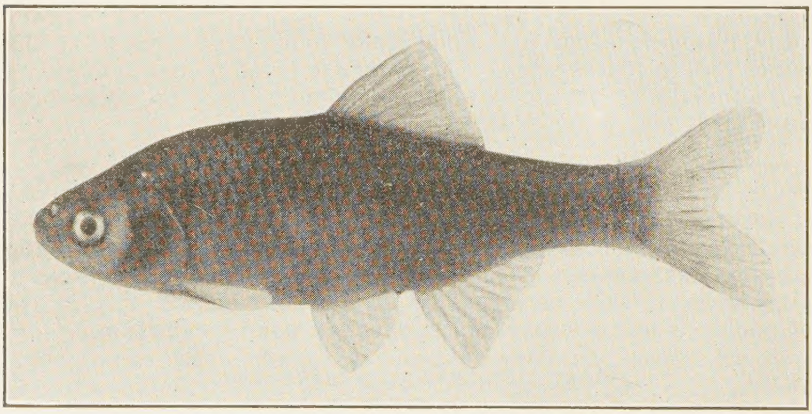

FIGURE 3.—Redfin (*Notropis lutrensis*).

to a length of 4 inches in a single summer. Full-grown fish often attain a length of 8 inches. With little effort one may produce 50,000 salable bait of this species per acre of water.

Golden shiners may be found in streams, rivers, pools, lakes, sloughs, and bayous. It is one of our most cosmopolitan minnows, and may be found in any section of the United States east of the Rocky Mountains.

Redfin (*Notropis lutrensis*).—This species, famous for bait in the Southwest, is a very attractive minnow; especially the male with his

red- or orange-colored fins and sides of a brilliant iridescent blue. The average length of the adult is 2.75 inches.

This minnow is very prolific in ponds. A. D. Aldrich, of Oklahoma, in unpublished data states:

> I believe it would be conservative to say that we produce 100,000 redfins during a season from a pond 40 by 80 feet.

The redfin begins spawning the first part of May and continues to spawn into the summer. This species also broadcasts its spawn over the vegetation.

The redfin may be found in small rivers, creeks, streams, and lakes. It is primarily a Western species and looks very much like the Eastern lemon fin (*Notropis whipplii*). It is not always easy to separate the two species. The natural range is from the Mississippi River drainage west to Wyoming, and from Canada to the Rio Grande.

Round shiner (*Hybognathus nuchalis*).—Wherever it is found in abundance this minnow has, in recent years, become popular among anglers as a bait fish. This species in the mid-Western and Southern waters grows to a larger size than the Eastern and Northern forms.

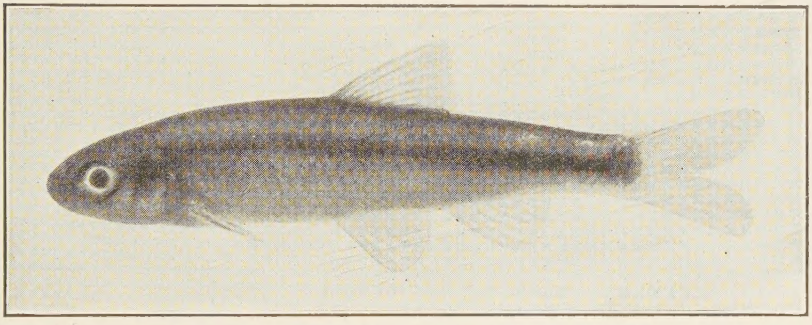

FIGURE 4.—Round shiner (*Hybognathus nuchalis*).

It is the larger variety that attracts such game fish as bass and pike. This minnow is less cannibalistic than the majority of our species.

The spawning season begins the last of April and early in May in Illinois and Iowa. In New York State it begins in June. Round shiners spawn naturally in ponds and during the summer of 1935 the writer obtained a production of 35,200 per acre from a small number of breeders. This production was from the smaller variety found in New York State. The mid-Western and Southern type seems to be more prolific and faster-growing; attaining a length of 6 inches.

This species may be found in rivers, creeks, ponds, and lakes. Its range has been reported from Georgia through Texas and northward to Canada.

Red-bellied dace (*Chrosomus erythogaster*).—This is a very showy minnow, especially the male, during the breeding season. Its vivid red belly, black lateral stripes and yellow fins compare favorably with the most highly colored artificial tackle.

The spawning season begins the first of May in Illinois and the adults attain a length of 3 inches. They will propagate naturally in ponds, and deposit their eggs on aquatic vegetation. Cooper, refer-

ing to the closely-related species *Chrosomus eos*, states (1935; p. 141):

> The eggs are normally, and so far as observed, deposited entirely in masses of filamentous algae.

This species inhabits streams, creeks, ponds, and lakes. Its distribution is rather spotted in the Northern part of the United States and through the East and Middle West.

ROCK- OR LOG-SPAWNING MINNOWS

This group of minnows, such as the blunt-nosed and black-head, spawn naturally in ponds and deposit their eggs in a mass on the underside, or ceiling, of rocks, logs, and the leaves of large vegetation, such as lily pads. Whole tiles, pieces of tile, flat rocks, and boards of approximately 6 inches in width make ideal spawning sites. These objects must be placed in the ponds where the minnows are to propagate. The rocks and tile must be about 6 inches above the bottom of the pond so that the minnows can work underneath and deposit their eggs on the ceiling of these objects. The pieces of tile or rock should

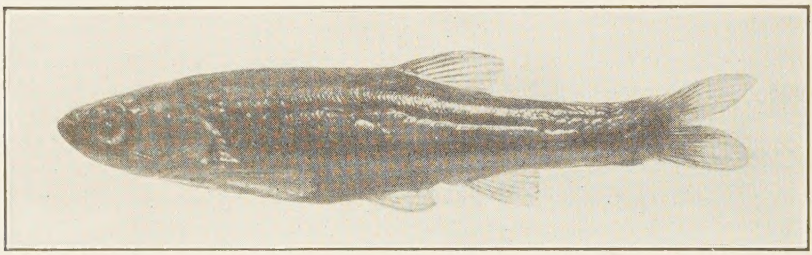

FIGURE 5.—Red-bellied dace (*Chrosomus erythogaster*).

be placed along the shore of the pond about 6 feet apart, with the nest 12 inches beneath the surface of the water. If there is a shallow end in the pond, the nests may be placed over the bottom in this section, in checkerboard fashion, about 6 feet apart. Pieces of board 6 inches wide may be stuck into the mud on a slant deep enough so they will remain in that position. They should be in about 18 inches of water.

While the female deposits her eggs they are fertilized by the male. As soon as her eggs are laid she will depart and the male will stay to care for them. The male often induces more than one female to deposit eggs on his nest. The same females may return to deposit more eggs on the same nest before the first eggs deposited are hatched. It is for this reason that eggs are found on the nest in different hatching stages. The number of eggs per nest varies from 36 to 12,000, depending upon the number of females depositing eggs there. The male performs three functions on the nest; protection, changing the water around the eggs, and keeping the nest clean. If the water is not kept in motion around the eggs they will not hatch. The same applies if the nest is not kept free from sediment, which smothers the eggs. If the male is left alone he will take care of all these essential functions.

The males of these fish grow larger than the females and when the breeders are taken from natural water the majority should measure between 2 and 3 inches. If all the broodstock measures over 3 inches,

the number of males will be much greater than females. It is advisable to have a greater number of females than males.

Blunt-nosed minnow (*Hyborhyncus notatus*).—The blunt-nosed minnow is often found in the angler's bait pail, but is seldom referred to by its proper name. It usually is called a small chub by anglers and bait dealers. It is a durable minnow on the hook and makes an excellent bait for crappie, perch, and sunfish. The larger individuals, 3 inches or over, are good bait for bass and pike.

Blunt-nosed minnows begin spawning the first of May and continue into the summer. Their eggs are deposited underneath rigid material such as rocks, tiles, and other objects, as described under the heading of this group. According to Van Cleave and Markus (1929; p. 539), females spawn in their second summer.

The blunt-nosed minnow is a prolific spawner in ponds, and large yields per water acreage can be obtained from this species. It is difficult to separate males from females except during and shortly before the spawning season when males may be easily detected by their darker coloration. In addition to this, the end of the nose and the

FIGURE 6.—Blunt-nose minnow (*Hyborhyncus notatus*).

top of the head of the male, at this time, bear small white spines known as pearl organs.

In nature, the blunt-nosed minnow may be found in streams, creeks, rivers, ponds, and lakes. Its general range is from Lake Champlain through the Great Lakes Basin and the North Atlantic Region as far south as New Jersey, and down the Mississippi River drainage to the Alabama River and the Rio Colorado of Texas.

Black-head minnow (*Pimephales promelas*).—The black-head minnow is a bait fish comparable to the blunt-nosed minnow.

In Ohio, Indiana, Illinois, and Iowa the black-head begins spawning by the first of May and continues into the middle of August. The eggs are deposited in masses under rocks, tiles, etc. The incubation period is about 5 days and the minnows attain maturity very rapidly. Markus (1934; p. 120) states:

> The minnows hatched in the early spring (generation 2) attained a length of 55 mm. in 2 months, whereas it took the late fry (generation 3) approximately 3½ months to reach this length.

Owing to the fact that the length of the tail fin varies between individuals of the same species and size, scientists have adopted a "standard length" which is the length of the fish from the tip of the nose to the base of the tail. A standard length of 55 mm. is equal to an entire length of approximately 2½ inches.

The black-head minnow is very prolific and is ideally suited to pond culture. Lord (1927; pp. 94–95) states:

> The production of blackhead minnows per acre on this basis stands at 201,971 at approximately 119 pounds.

Markus (1934; p. 118) attained a production of 4,144 young from a single pair of black-heads. It is difficult to distinguish the males from the females before the spawning season for the males do not possess their dark bronze color and pearl organs prior to this time.

This species may be found in streams, creeks, small rivers, ponds, sloughs, and lakes. Its distribution is rather spotted over the United States East of the Rocky Mountains. It has not been reported from the extreme Southeastern States.

STREAM-SPAWNING MINNOWS

These minnows, which include the horned dace and stoneroller, have entirely different spawning habits from the pond-spawning groups. They deposit their eggs in shallow running water. The male usually

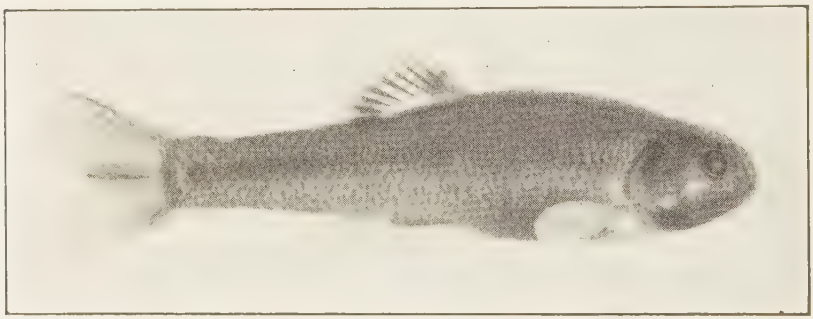

FIGURE 7.—Black-head minnow (*Pimephales promelas*).

builds the nest in advance of the spawning period by excavating sand, gravel, and small stones near riffles. Not very much care is ordinarily given to the eggs after they are deposited, although the males of some species stay around the nest to protect the eggs.

The fact that these minnows do not naturally propagate in ponds is no reason why they cannot be so reared. Greater production per number of eggs of these species may be obtained than from the group where the breeders are left in ponds to spawn naturally. The problem of adults eating their young is eliminated. The eggs from these species have to be taken artificially and hatched in running water.

HATCHING TROUGHS

The method of hatching is similar to the hatching of trout eggs, where the eggs are put on trays and set in troughs of running water. Troughs may be of any dimension, although 10 inches wide, 6 inches deep, and 12 feet long is ideal. A flow of 6 to 10 gallows of water per minute should run through this trough.

The tray frame to fit the above-mentioned trough may be made from ¾-inch wooden strips. The frame should be 9½ inches wide and 16 inches long. A fine grade of cheesecloth, or galvanized screen dipped in

asphaltum, is tacked onto the wooden frame to hold the eggs. The eggs are spread out over the tray while it is under water. The trays are wedged into the trough at an angle to the surface of the water. The end of the tray next to the inlet should be set on the bottom of the trough and the end farthest from the inlet should be 1 inch beneath the surface of the water. The trough must be screened at the overflow end. The overflow should be regulated so that water is maintained at a depth of 5 inches in the trough. The outlet end of the trough should be about 1 inch lower than the intake end. The water coming into the trough must be clear and have a temperature of 65°–85°. A city supply may be tapped, or the trough lowered into the bed of a small stream to permit the required amount of water to flow through. After the hatching equipment is set up, the eggs may be taken from minnows inhabiting natural streams.

TAKING OF EGGS ARTIFICIALLY

Many of the bait minnows that spawn in flowing water give off their eggs and milt readily and the spawn may be taken artificially. The taking of eggs and milt from minnows is not a difficult task to perform and a study of the following procedure will enable one to execute the operation with ease.

The breeders are usually seined from the streams. When the seine haul is made, without lifting the seine from the water, an attempt should be made to spawn the males and females in order to pick out the ones ready to give off their eggs and milt. Ripe females that are ready to give up their eggs should be placed in a separate container. Never strip females until ripe males are at hand.

To determine if minnows are ripe, in removing them from the seine, proceed to strip them. If the eggs come from the vent of the female as soon as a little pressure is applied to her belly, she is ripe and ready to spawn. The same procedure applies for milt in the case of the male. If the eggs come hard from a female and her belly feels rigid, or if bloody eggs appear on gentle stripping, she is not ready to release her eggs. Save her for a later date or release her in the stream. In case a female be stripped and no eggs obtained, and her belly be soft and flabby, she has already released her spawn in the stream.

In the beginning of the spawning season it is very easy to find ripe males, for all the adult males will be more highly colored and ready for spawning. They remain in the spawning mood for some time. However, ripe females are harder to find, and continue to become more difficult as the spawning season progresses.

To strip or spawn the fish, hold it as firmly and gently as possible, over a dampened pan, at such an angle that the eggs or milt will flow naturally towards the vent. With the thumb and forefinger gently press the belly of the fish, beginning near the head and moving toward the vent. Repeat this process until the fish will no longer give off eggs or milt. As soon as the eggs are stripped into the pan, the milt is immediately added to the eggs by stripping the male in the same manner as the eggs were taken from the female. This milk-colored milt contains the sperm that fertilizes the eggs. After the male is released, stir the milt and eggs gently with the finger so that the milt is sure to come in contact with all the eggs. Four or five

pairs of fish may be stripped into the same pan. It is important to strip milt from the male on the eggs immediately after stripping each female. The eggs should be stirred gently every few minutes with the finger to prevent them from sticking to the pan, for the eggs of many of the minnows are adhesive.

About 10 minutes from the time that the eggs are taken they begin to lose their adhesiveness. After the last pair of minnows has been spawned, let the eggs stand for about 5 minutes and then pour off the excess milt by slowly tipping the pan to one side. Then slowly add water from the stream by letting it run in on one side of the pan until it is about half full. After the eggs have settled to the bottom, slowly pour off the water again. Repeat this process until the eggs appear to be free from excess milt or other material. The eggs may then be transferred to a larger can for transportation to the hatching trough. Water must be first put into the container and the pan with the eggs lowered into the water. By tipping the pan slowly, the eggs will float out of the pan into the container. The best method is to have a number of spawning pans and transport the eggs to the hatching trough with the pans one-fourth full of water. Never give

FIGURE 8.—Horned dace (*Semotilus atromaculatus*).

newly fertilized eggs sharp or hard bumps. After the eggs are fertilized and cared for in the field, they should be taken to the hatching troughs as soon as possible.

RELEASING THE FRY

The eggs of these minnows hatch in from 4 to 10 days, depending upon the temperature of the water. The warmer the water, the faster the eggs hatch. However, best results are obtained if the temperature is not above 85°. When the eggs hatch, the fry will rest on the bottom of the trough and, at this stage, they are helpless. Cut down the flow of the water through the trough so that the current will not carry them against the screen. About 24 hours after hatching is completed they may be released into the rearing pond. The fry will live on their yolksacs for a few days.

Horned dace (*Semotilus atromaculatus*).—This minnow is often referred to as a creek chub. The horned dace is the prize bait of most anglers. Forbes and Richardson (1920; p. 123) state:

> This species is reported by Jordan to reach a length of a foot and to be excellent bait, when of the proper size, for bass, wall-eyed pike, and pickerel.

The horned dace may be compared to a good hunting dog—when on the hook he works continually and is one of the hardiest of minnows.

The horned dace is one of the first spawners in the spring. All the adults that mature in the fall spawn during the early part of the following spawning season. Spawning is prolonged by the females that matured late the previous fall and during the early part of the spring spawning period. Horned dace are easily stripped, for they give off their eggs and milt readily, and the number of eggs per female is relatively large, depending upon the size of the individual.

The horned dace grows very fast the first summer. Markus (1934; p. 95) states:

> Many of the young hatched from these eggs and reared in a pond attained a length of 3½ inches by the latter part of September.

This length was attained at Rochester, N. Y. Leonard (1927; p. 39) found year-old individuals 3.7 inches long. These are standard lengths; that is, the length of the tail fin is not included.

Horned dace have a wide distribution in the United States and are found in small streams, creeks, and rivers in the spring of the year. Late in the summer they may be found in quiet water. They have

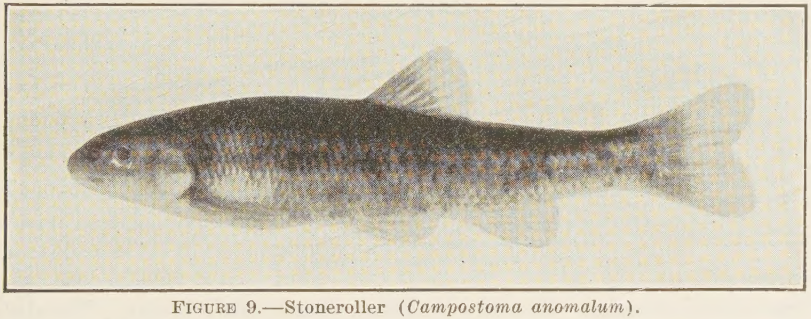

FIGURE 9.—Stoneroller (*Campostoma anomalum*).

been reported from Wyoming to the Hudson River and from Canada to the Gulf of Mexico.

Stoneroller (*Campostoma anomalum*).—This minnow is usually tenacious of life and is one of the hardiest on the hook. It is common to find individuals 6 inches long.

The stoneroller spawns early in the spring. It ascends the fast-running streams to spawn and then goes back to the quiet pools in the stream. The male, during the spawning season, often has the entire upper part of his body covered with pearl organs. This species is easily stripped. Their distribution in the United States is wide and spotted, being rather abundant in the Great Lakes Region, along the South Atlantic, and through the Middle West to Wyoming and Texas.

NATURAL STREAM SPAWNERS

This group of minnows, such as the common shiner, usually spawns in clear streams with a gravel or rock bottom. The males build the nest in the gravel and sand in advance of the spawning period. They stay over the nest and wait for ripe females to come

and deposit eggs while he fertilizes them. In most cases the males stay with the nest. The spawning is similar to that of bass. It is rather difficult to obtain the eggs and milt from this group artificially. In some species, such as the bass, the females will not give up their eggs without injuring the eggs and killing the fish.

Minnows of this group may be propagated in small streams that are dammed off and screened, or by having the stream run into a pond. The stream is used for the natural spawning of the breeders and the pond for rearing the young.

Common shiner (*Noptropis cornutus*).—This is one of the most beautiful and conspicuous minnows of our streams. Its coloration, size, and durability makes it one of our best bait minnows.

The writer has tried a number of times to take the eggs from this species artificially, but has been unable to do so. No record of artificial spawning is recorded in the literature. However, the author did get a fair production of common shiners in a small stream that was dammed off. The breeders were left to spawn naturally.

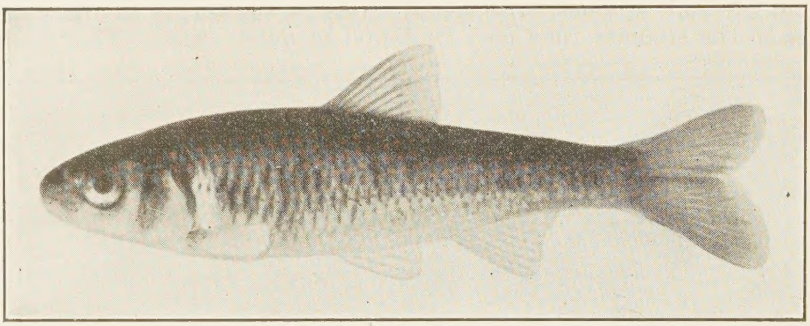

FIGURE 10.—Common shiner (*Notropis cornutus*).

The common shiner inhabits streams, creeks and rivers. Its distribution is through the Northern section of the United States, from Wyoming to Maine.

ARTIFICIAL FEEDING

Minnows can be successfully produced in ponds with sufficient aquatic vegetation. Fertilizer, such as cow and sheep manure or small quantities of sewage reduction sludge, added to the water stimulates the growth of vegetation and also serves as food for daphnia or waterfleas, nymphs, and larvae of insects. A bushel of either cow or sheep manure should be added to a quarter-acre pond every 10 days. Care must be exercised, however, not to over-fertilize.

Minnows also feed directly upon a number of artificial foods such as shrimp meal, fish meal, cottonseed meal, middlings, bran, tankage, dried skim milk, and soy-bean meal. A mixture of shrimp or fish meal with some of the grain meals made into a mash and dried and ground, makes a good food. Bread scraps are also excellent. Any of these foods that are not directly taken by the minnows serve as fertilizer for the aquatic plants, waterfleas, and nymphs of insects, which in turn make natural food for the minnows.

NUMBER OF SPECIES PER POND

It is better to rear only one species in a pond, but frequently two species will do fairly well together. In those species where the eggs are taken, and hatched artificially, two or more species may be released in the same pond.

The best results will be obtained if an equal number of males and females are released to spawn naturally. The number of brood fish to be placed in a pond for natural spawning depends upon the number of breeders available and the size of the pond. A satisfactory crop may be obtained from 50 pairs of breeders in a quarter-acre pond, but it is more desirable to stock this size pond with 100 to 200 pairs.

INSTRUCTION FOR CARE OF BAIT MINNOWS IN PAILS

Bait dealers should instruct anglers in the care of the minnows they purchase. They should not overcrowd the angler's container, even though it may mean a smaller sale. If the minnow pail is crowded the angler will probably lose his bait before he gets to fishing waters. The angler would then accuse the dealer of having weak minnows and would not return for further purchases. When the minnow pail is not provided with an aeration device the purchaser should be advised to aerate the water in his pail at frequent intervals while traveling on the road. Aeration of the water, or fanning the fish—a phrase that is often used—is accomplished by dipping up water and pouring it back into the pail. Repeat this process about a dozen times and the fish will have good water again. This operation picks up oxygen from the air and excess carbon dioxide in the water is released into the air. It is much better than changing or adding water from different water supplies.

If the angler has a long trip to make, advise him to put ice into the water with his minnows. Add the ice slowly until the temperature reaches about 55°. If the water temperature is kept at this point, the minnows will need less fanning, for cool water slows down the rate of breathing and picks up more oxygen than warm water. When the angler reaches the fishing ground, if the water in the minnow pail is colder than the body of water to be fished, warmer water should be gradually added to the pail. As soon as this is done the angler usually places the pail in the water to be fished. If this procedure is followed, the minnows will be more active and work better on the hook.

IDENTIFICATION

Fish are identified by keys. In order to work a key of the fishes, one must have some scientific training and be acquainted with the morphological structure of the fish. Pictures of the different species are incorporated in this text which will assist in determining the species described, since they differ greatly in gross appearance.

If the propagation of a certain species is contemplated and you are not certain that the species at hand is the desired one, a few specimens may be sent to the Bureau of Fisheries, Washington, D. C., and the Bureau will identify them for you. To prepare specimens

for mailing, preserve them in a formalin solution. Formalin may be purchased from a drug store. To one part of formalin add nine parts of water. This will give a 10 percent solution. The solution should be made up in a glass container; usually a quart fruit jar is used. Place the minnows to be identified into the 10 percent formalin solution and leave them in the jar for at least 2 days. Then pour off the liquid formalin and mail the jar containing the minnows to the Bureau.

CRAYFISH

The crayfish, especially the soft-shelled individual, is very popular among anglers as a bait. In some sections of the country crayfish are referred to as crabs. This, however, is a misnomer for they are not true crabs. Crayfish will propagate naturally in a pond and they may be produced in the same pond with minnows. The shallow end of a pond in which crayfish are propagated should have a sandy, inclined slope running in depth from zero at its edge to a depth of 6 inches about 15 feet out in the pond. Here the young crayfish may be found during the night and early morning. This shallow water also makes a convenient place to seine for them. This is especially true of that species of crayfish known as *Cambarus virilis*.

Crayfish mate in the early fall. The breeders should be placed in a pond during August for production the next year. Spawning usually occurs in the springtime and mating in the fall, although both may occur during the winter. Eggs may often be found in the late fall. The eggs resemble a bunch of berries and are carried by the female underneath her abdomen, attached to her swimmeret appendages. They are so carried until they hatch. As soon as the eggs hatch, the young cling to the mother's swimmerets and remain with her until they can shift for themselves. The number of eggs carried by a female depends upon her size. Langlois (Bull. 132) finds that the average number of eggs carried by a 44-mm. (1¾ inch) female is 80, while a 102-mm. (4 inch) female carries 374. The eggs are of a dark color and about the size of BB shot.

Crayfish may be taken from natural waters such as swamps, lakes, rivers, creeks, and streams. They feed on aquatic vegetation and decaying vegetable and animal matter. They also attack living animal life if it is not fast enough to keep out of their way.

All crayfish go through several soft-shell stages. Their outside shell is a chitinous skeleton to which their muscles are attached. The shell does not grow with the body so the crayfish sheds his outer shell and grows a larger one. As soon as he sheds the outer shell he becomes soft-shelled until the new one becomes hard. The crayfish that hatch in the spring molt, or shed their shell a number of times the first summer. So a greater number of soft-shelled individuals may be found among this group. These medium-sized individuals are preferred by anglers.

There is but one satisfactory method of making hard-shelled crayfish soft-shelled. That is by feeding them and developing growth, causing the crayfish to shed the old shell frequently. When a bait dealer propagates his own crayfish for bait, he may sort out the soft-shelled crayfish from his pond every 2 or 3 days and have soft-shelled individuals on hand continually during the summer. These indi-